Rising River Challenges

Hydrographic surveyors rely on a remotely operated survey vehicle mounted with a single-beam echo sounder and RTK GPS to survey water crossings for pipelines.

By Melissa Kelley and Adrian McDonald, PhD

Fallen trees, vegetation, and steep terrain combined to present a significant mobilization challenge.

The construction and maintenance of cross-country pipelines for natural gas and liquids relies on accurate survey data. Often, a pipeline route will cross under rivers or other inland water bodies, so accurate hydrographic surveying of the water crossings is a key component of the overall project. However, the hydrographic survey location can often be remote, with poor road access, which leads to potential challenges mobilizing even a small hydrographic survey crew and equipment.

The pipeline survey team at Shafer, Kline & Warren, Inc. (SKW) of Lenexa, Kansas, was faced with a pipeline hydrographic survey challenge that looked like it could be solved only with substantial expense and plenty of old-fashioned inconvenience. In late 2011, a 110-mile project was started, spanning two midwestern states and crossing the Whitewater, Little Miami, and Great Miami rivers. Design survey data included property boundaries, topographic features, and construction obstacles. Planned waterbody crossings for the pipeline were to be constructed using a horizontal directional drilling technique: a steerable trenchless method of installing underground pipes, conduits, and cables along a prescribed bore path by using a surface-launched drilling rig. Accurate mapping of these water crossings was essential to the drilling process to avoid contravening depth-of-submersion requirements by regulating agencies; the pipeline must be buried deep enough to be safe.

Some of the most difficult areas to assess in the pipeline design process can be the water crossings where a few feet of increase in the depth of the bore under the water can require hundreds of feet more in total bore length. The pipeline drill path can be gently curved only as much as the pipe diameter and thickness will allow, so the drilling station has to move farther from the water crossing as the submersion depth increases. Therefore, accurate survey data is needed not only to ensure that the pipeline is buried deep enough for regulatory approval, but also to ensure that it is not buried too deep because of the resultant increase in horizontal directional drilling bore length, required drilling time, and cost.

At the start of the project, all of the waterway crossings were deemed to be safely fordable, and the hydrographic

survey plan was simply to use wading depth measurements. However, rising waters from winter rainfall started to jeopardize the aggressive, fast-paced delivery schedule promised to the client. It became clear that the rivers were simply not safe to cross by wading. SKW reviewed hydrographic survey options for this evolving project and, at first, could not see a way around the challenge with conventional survey procedures and equipment. Then they looked to the growing area of remotely operated survey vehicles to solve the problem.

Practical Challenges

Surveying of shallow, slow-moving rivers or small ponds can be accomplished by a single surveyor with a pole-mounted GPS system and a field data collector. With a minimum requirement for manpower and no need for specialized hydrographic equipment, this method is cost effective but limited to shallow water with safe wading conditions. For rapid surveying of large areas with the maximum possible bottom coverage, use of a multi-beam echo sounder on a dedicated survey vessel offers a highly capable solution but at a high price.

Between these two extremes, the solution of a single-beam echo sounder and sub-meter or RTK GPS mounted on a small boat with a gasoline outboard or trolling motor offers survey flexibility at a relatively low cost. However, even the

Surveyors can control the survey boat by sight, but using navigation data from the shore laptop helps where it may be difficult to see the boat.

small, manned boat will not be suitable for some survey locations, and an even smaller survey boat may be needed. Remotely controlled boats have been successfully used in place of manned boats for survey projects in many different environments. With a relatively small size and low draft, a remotely controlled vessel can be used in shallow water, is easily transported, and may be used where it is unsafe for a surveyor to work on the water such as effluent treatment ponds, mine tailing ponds, or rivers with high water velocities.

However, developers of remotely controlled survey boats have typically focused on larger craft for coastal surveying, with limited applicability for river or inshore surveying where a smaller and faster vessel may be required. The inclusion of autonomous navigation control with integrated RTK GPS electronics has resulted in a tendency for remotely controlled survey boats to be rather more expensive than a fully outfitted, regular survey boat. While reviewing remotely controlled survey options for the pipeline river crossings, SKW surveyors contacted The Oceanscience Group (Oceanside, California), manufacturer of the Z-Boat 1800 hydrographic survey boat, hoping that it would meet the pipeline route survey requirement for a small, lightweight, and high-performance vessel that could carry SKW's own survey equipment (see the sidebar at left for details on this boat).

SKW determined that the Z-Boat 1800 was suited to the pipeline survey challenge, and the race was on to learn the new survey procedures required to generate the bathymetric information needed from a remote platform. SKW surveyors needed to be able to use the more complex hydrographic survey software package—HYPACK—to manage the survey workflow and monitor the survey data quality while the survey was progressing. After setting up the survey plan, they drew the survey lines for each water crossing.

To conduct the survey, the remote boat would be driven up and down the

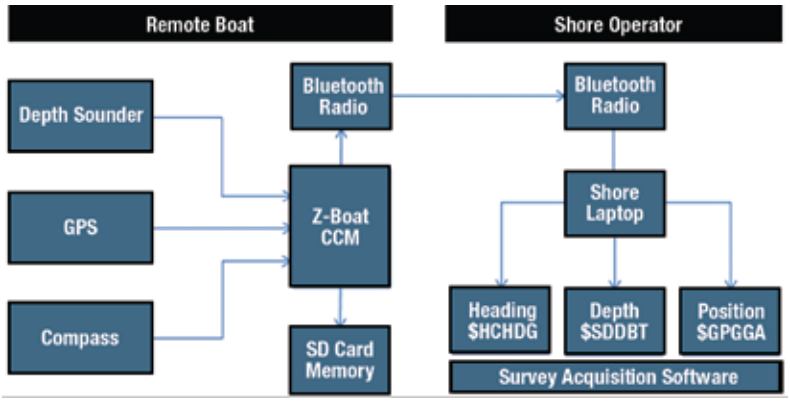
Solving the Problem of Getting Data to Shore

The United States Geological Survey (USGS) commissioned Oceanscience to develop a high-speed instrumentation boat because they recognized the potential benefits of a small and portable remote survey boat for river velocity surveys during dangerous flood conditions. The boat was initially deployed by USGS technicians using acoustic Doppler current profilers (ADCP) during potentially life-threatening flood conditions. Later, it became clear that the remote platform would be suited to inshore hydrographic surveying with bathymetry and GPS equipment installed in place of the ADCP, and that's how the Z-Boat 1800 was developed.

Dr. Ron George, president and founder of Oceanscience, said, "Our approach was to focus on developing a solution that was in line with the needs of the small boat surveyor, with costs minimized by accommodating the surveyor's existing survey equipment, in particular expensive RTK GPS. The biggest challenge was … to get the survey data to shore with no errors. We ended up using industrial Bluetooth communication systems, which has since proven to be surprisingly robust and reliable."

Developments in industrial Bluetooth radio modems have afforded the potential for inexpensive and long-range (>0.5km) serial data communication. However, sending multiple data streams such as from a remote survey boat's GPS and depth sounder over a Bluetooth radio link may be compromised by latency issues; that is, data must be received by the acquisition computer exactly time-synchronously or errors will appear.

Avoiding latency is a key element of remote boat design, with the simplest solution being to multiplex all data on the boat before transmission to the shore over a single radio channel. Multiplexing data on a remote boat can be made relatively simple by using the NMEA 0183 message format available on typical survey instrumentation. On the Z-Boat 1800, the depth sounder, GPS, and magnetic compass are connected to the Control and Communications Module (CCM) using standard RS232 serial cables. NMEA 0183 messages from each instrument are fed into a PC board inside the CCM, which multiplexes these data streams and outputs a single combined NMEA 0183 data stream to a local SD memory card and to a Bluetooth radio modem. The radio modem then transmits the boat's heading, position, and current depth from the sonar to the shore laptop where this data may be displayed and recorded using a hydrographic survey software package.



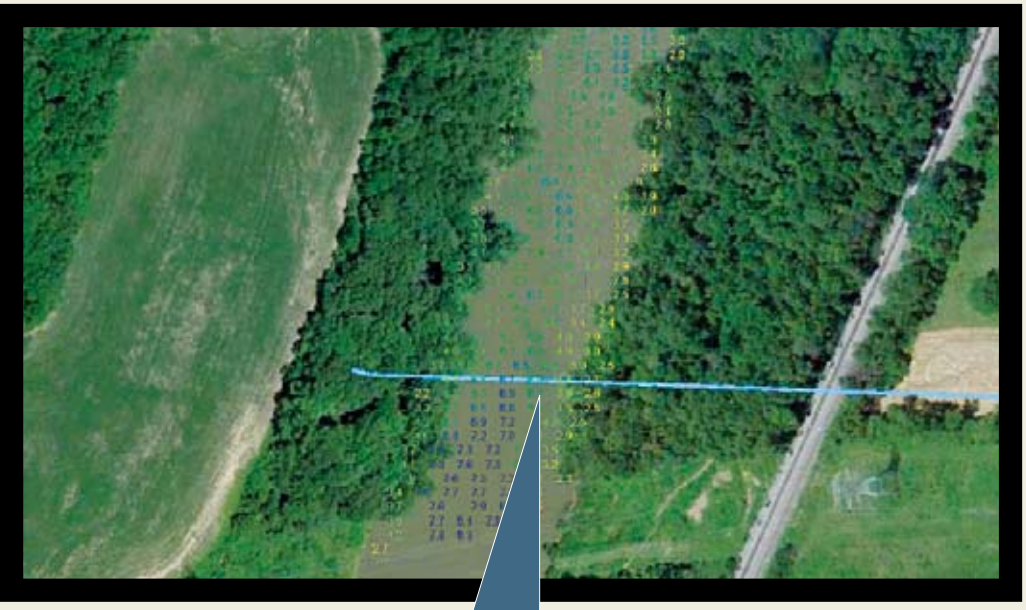
tightly spaced survey lines by the operator while he watched the display on the shore laptop to keep on track. All that remained was to get the survey boat to the water crossings. (An SKW employee naming contest christened the boat the PROWLER: an acronym for pond, river, ocean, waterway, and lake echosounder remote.)

Safety Maintained

In order to reach the most remote survey sites, the PROWLER was secured to the back of an all terrain vehicle (ATV). Once at the river, the boat was deployed through the numerous fallen trees and logs that made access challenging; even the deployment of PROWLER was difficult. "We could find only one safe spot to get the boat into the water between the trees, and even then we had to take off the GPS antenna so we could fit the boat under the tree branch," recalls Scott Corwine, lead hydrographic surveyor and PROWLER custodian. "It was more like a video game than a survey job really, once we had the boat in the water. With some practice on a local lake beforehand and a little aptitude, survey lines can be run just as well or even better than with a manned boat."

PROWLER was used on three river crossings and five small water bodies where its fast mobilization time made it preferred over the manned survey boat even where there was adequate access. With the focus on safety paramount for construction work, PROWLER was able to visibly demonstrate the commitment to safe operations at SKW. "After watching PROWLER in action, the client could see that we were taking safety seriously and were thinking with safety at the forefront of survey planning," said Scott.

Since the completion of the pipeline project, the full value of a remote survey boat is being realized at SKW with PROWLER in almost continuous use. Reflecting on the SKW experience, Corwin notes, "The boat is still used mainly where access is challenging, but this is turning out to be rather common! Surveys include a post-dredging survey on a wastewater treatment pond in Chetopa, Kansas, and a scour survey of a power structure where the concrete piers were being eroded away. The scour survey was particularly satisfying; the scour hole that PROWLER identified was promptly filled with gravel before several thousand people had the lights go out."



SKW crew used hydrographic survey software to monitor the data quality while the survey progressed (the pipeline route is marked in blue)

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